DRAINAGE AND UTILIZATION OF FIREDAMP

BY J. VENTER AND P. STASSEN

* * * * * * * * * **Information Circular 7670**

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FOREWORD

This paper on the drainage and utilization of firedamp, by J. Venter and P. Stassen of Belgium, was prepared in response to an invitation by the Bureau of Mines to acquaint the American coal-mining industry with the considerable progress that has been made in Belgium and other European countries on this subject.

Although the degasification of coal beds has been considered from time to time by American engineers, as discussed in Bureau of Mines Report of Investigations 3233, no commercial methane recovery systems have been installed. In fact, methane drainage was not necessary as long as shallow beds giving off only small amounts of firedamp were being mined. However, as coal mining proceeded to the deeper, more gassy beds, the greater quantity of methane released increased the explosion hazards and the cost of ventilation if these hazards were to be avoided. This gradual change that has been taking place in American conditions has led American mining engineers to become interested in recent progress in Europe and prompted theBureau of Mines invitation for preparation of this paper.

European experimental research and development of commercial installations were begun in the Ruhr, Germany, at the Mansfield mine in 1943 and at the Hansa mine in 1944. After the war interest in methane recovery spread in the coal fields of western Europe and those of Great Britain. In 1952 about 60 collieries had installed experimental or commercial installations to drain firedamp.

Belgium, with its deep-lying gassy beds, has made excellent progress. In 1952, 13 collieries in Belgium recovered an average of 7,000,000 cu. ft. of firedamp daily from a production of 110,000 short tons of coal.

This and other work show that the recovery of methane from highly gassy coal beds is feasible and advantageous. It lowers the cost of ventilation and decreases the hazard of explosions, and the recovered methane is a valuable fuel for local or distant use.

Although the United States, with its generally shallower coal mines, does not have many situations as favorable for methane recovery as the much deeper European and British mines, there are a few locations, such as the Pocahontas field in West Virginia, where methane drainage has been considered. (See Lawall, C. E., and Morris, L. M., Occurrence and Flow of Gas in Pocahontas No. 4 Coal Bed in Southern West Virginia: Trans. Am. Inst. Min. Met. Eng. Coal Div., vol. 108, 1934, pp. 11-30.) Application of the newest developments abroad might be advantageous in lowering ventilation costs in these highly gassy mines.

J. Venter and P. Stassen, of the Institut National de l'Industrie Carbonniere of Belgium, have been actively concerned with the outstanding developments in Belgium and have a comprehensive knowledge of progress generally in the drainage of firedamp. The coal-mining industry of the United States is deeply indebted to them for this informative publication.

ARNO C. FIELDNER
Chief fuels technologist
Bureau of Mines

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by

J. Venter[1] and P. Stassen[2]

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[1] Director, Institut National de l'Industrie Charbonniere, Belgium (INICHAR).

[2] Chief engineer, Institut National de l'industrie Charbonniere, Belgium (INICHAR).

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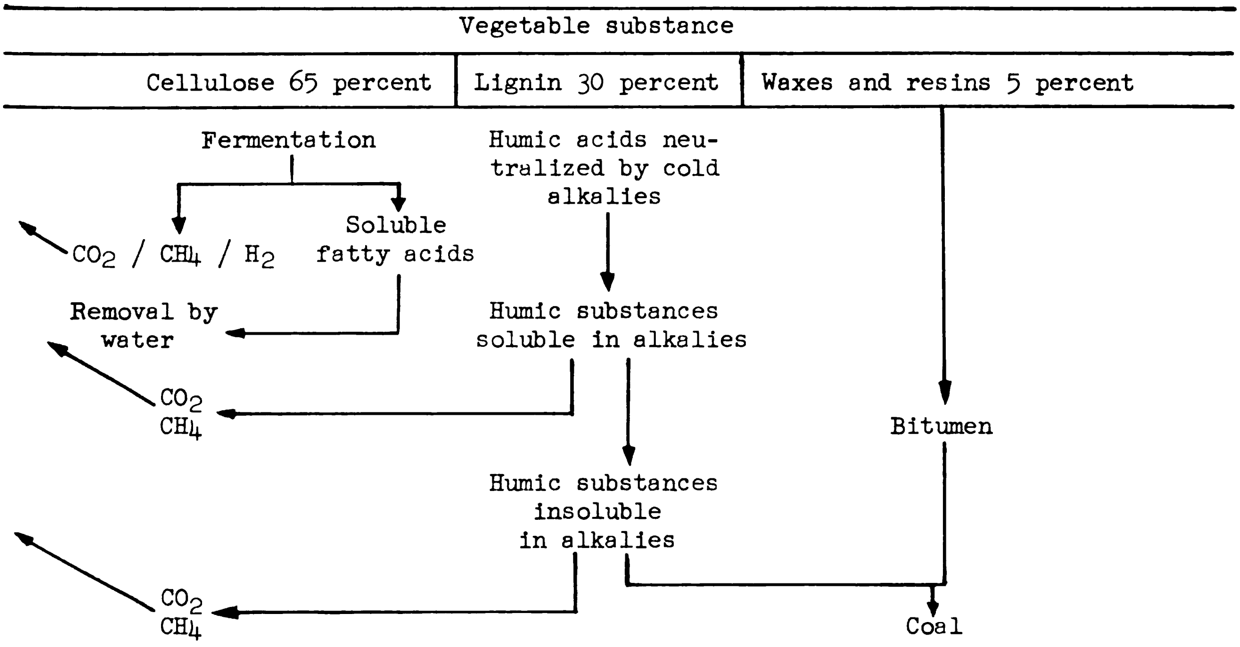
ORIGIN AND NATURE OF FIREDAMP

The history of firedamp is the same as that of coal: The initial stage was the accumulation of vegetation, which was converted into peat under certain local conditions, then lignite, bituminous coal, and finally anthracite. These deposits ceased to increase owing to inundation that deposited earthy sediment, sometimes as much as several tens of meters (several tens of yards). The vegetable matter, whether it was covered with sediment or not, began to ferment.

The basic organic components of the vegetable matter are: Cellulose, lignin, and wax and resin in varying proportions, according to the different kinds of vegetable matter. There are, in addition, some impurities, generally mineral.

The following table outlines the processes undergone by the original vegetable matter, which is hardwood containing 65 percent cellulose, 30 percent lignin, and 5 percent wax and resin. A softwood (poplar, for example) would contain more cellulose and less lignin.



In the fermentation the cellulose was destroyed first. The gases given off consisted chiefly of carbon dioxide and secondarily of methane or hydrogen, according to the kind of bacteria. These gases were totally discharged into the atmosphere. Fermentation of cellulose occurs in peat today; in a given layer, the percentage of cellulose diminishes toward the bottom.

After the biological stage and the fairly complete elimination of cellulose, the slower evolution of lignin began.

The elementary analysis shows that, if the percentages of oxygen and hydrogen decrease in all coals, from bituminous coal with 18 to 40 percent volatile content to anthracite, the reduction in the percentage of hydrogen considerably exceeds that which would explain the production of water. Hence, hydrocarbon and prabably hydrogen are eliminated.

Work carried out before the war in Belgium, at the Institut National des Mines, confirmed these views. Experiments demonstrated that bituminous coal with 35 percent volatile content decomposes in a manner commensurate with the release of methane and the subsidiary release of hydrogen after the temperature reaches 100° C. (212° F.).

The phenomenon also occurs at the normal temperatures of the seam. The discharge of gas is certainly very small, yet it must be admitted that, even at the present stage of coalification, there is a slow but continuous production of methane and a subsidiary production of hydrogen.

These gases, and firedamp in particular, which have been produced over countless thousands of years, were discharged into the atmosphere as long as the covering deposits were permeable enough.

Lignite and brown coal, which are usually found at shallow depth in loose ground, are free from firedamp. With these low-rank coals, there is another reason, explained in recent papers by Patteisky, namely their hydrophilic nature.

The thicker and more compact the covering deposits become the more impermeable they are; thus they make emission of the gas more difficult. However, the impermeability of the encasing rocks is far from being complete, and a considerable proportion of the gases slowly penetrates through the layers.

Hydrogen is diffused about three times as fast as methane; consequently, losses caused by diffusion affect hydrogen particularly, and fairly considerable quantities of methane can be expected to be found in coal seams, depending on the rate of gas production and the permeability of the encasing rocks.

To summarize, firedamp began as marsh-gas when the vegetation in the marsh was laid down; formation continued throughout the long transformation into peat, lignite, and coal, and today coal seams continue to produce firedamp, the quantities being greater according to the rank of the seams. This phenomenon is speeded by a rise in temperature.

A considerable proportion of all this firedamp has penetrated through the rocks, which have become inpregnated with it, and has been dispersed in the atmosphere. Another part has remained in the coal seams, in a way discussed later, under a certain pressure, which may be very high.

Very accurate analyses of 60 virgin firedamp specimens, taken under pressure in coal seams, were carried out in Belgium. The minimum, average, and maximum percentages of the various components follow:

Percentage	CH_4	N_2	CO_2	H_2	$H_2 + N_2$	C_2H_6
Minimum	92.9	0.0	0.03	0.000	0.001	0.02
Maximum	99.6	6.1	3.38	.235	.171	2.79
Average	97.0	1.6	.84	.019	.047	.53

ERRATUM

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For H_2 + N_2, substitute He + Ne.

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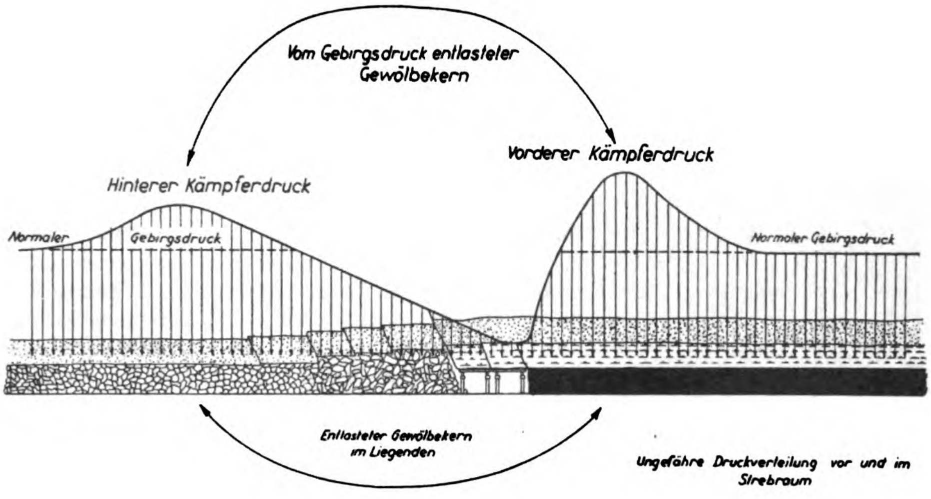
Vom Gebirgsdruck entlasteter Gewölbekern
Vorderer Kämpferdruck
Hinterer Kämpferdruck
Normaler Gebirgsdruck
Normaler Gebirgsdruck
Entlasteter Gewölbekern im Liegenden
Ungefähre Druckverteilung vor und im Strebraum

Figure 1. - Distribution of rock pressures near an advancing face, according to Spruth and Walker.

Normaler Gebirgsdruck - original pressure
Vorderer Kampferdruck - front abutment load
Hinterer Kampferdruck - rear abutment load
Vom Gebirgsdruck
Entlasteter Gewölbekern - relaxed core of the vault
Idem im Liegenden - idem, in the floor

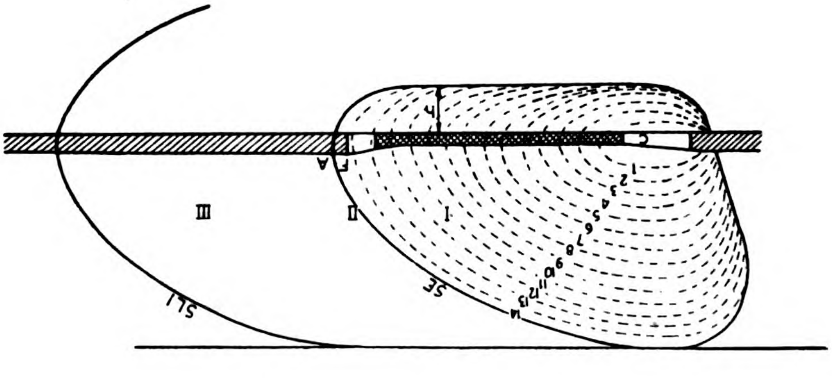

Figure 2. - Distribution of rock pressures near an advancing face, according to Labosse.

For practical purposes, firedamp may be considered as methane, which, on the average, forms 97 percent of its composition.

RELEASE OF FIREDAMP

Belgian coal fields have considerable firedamp, and research into firedamp has always been very extensive. No mention will be made of the work done about 50 years ago by Watteyne and Stassart, but the more recent research work may be quoted. This was performed under the direction of Breyre, managing director of the Institut National des Mines, in 1934 and 1936. The conclusions reached were the forerunners of those of the German experimenters, especially Forstmann and Schulz, reached immediately before and during the war. Their work culminated in the following general conclusions: In a mass of virgin coal under normal rock pressure the release of firedamp is slight, even in the case of a distinctly gassy seam in which the firedamp is contained under high pressure.

The release of pressure on a seam of coal, usually caused by mining of the seam itself or an adjacent seam, causes a discharge of firedamp, which varies according to the pressure release. This release brings about a noticeable increase in the permeability of the seam to firedamp.

The release of firedamp and increased permeability following a decrease of pressure form the basis of the technique of drainage. Therefore, it seems essential to give a very brief outline of the theories relating to rock pressure and movements in working places, which were the outcome of the international conference held at Liege, Belgium, in April 1951.

At the depth of H m (feet) beneath surface level, the vertical pressure of coal measures is expressed by H d, d being the density of the superincumbent rocks. At a depth of 1,000 meters (3,281 feet) this pressure is 250 atm.; it considerably exceeds the breaking load of the rocks. If the latter are not crushed, it is because they are subjected to laterial pressure, which is also very high. The remaining orogenic stresses may cause high extra strain. Therefore, below a certain depth in the coal-bearing rocks, a system of stresses exists in all directions, exceeding the breaking load of the rocks. It can easily be seen that any excavation will cause a relaxation of pressure in the surrounding rocks toward the cavity, with corresponding cracking and disintegration. This phenomenon occurs around an advancing face that is surrounded by a zone of rocks, the condition of which is changed by reason of the cavity created by working.

At the face, the pressure exerted by roof and floor pressure, which can be accurately measured, is slight compared with the original pressure H d. It is about 1 to 3 percent of H d, and corresponds to the weight of a thickness of 10 to 15 m. (33 to 49 ft.) of coal-bearing rocks at the usual depths. As the load of superincumbent rocks remains, it mustbe assumed that it is transferred around the face by a process concerning which the opinions of the various writers differ:

Spruth (German) and Walker (British) ascribe to the coal-bearing rocks the properties of elastic matter and suggest thatthis transmission occurs through the rocks acting like a relieving vault in masonry. The load at the support points in front and behind causes an increase in the original pressure, which varies between 25 and 100 percent of H d (fig. 1).

Labasse (Belgian) considers the face as a gallery, the axis of which moves parallel to itself. According to him,each face is surrounded by three zones (fig. 2): The zone of relaxed rocks at low pressure (I); the high-pressure zone along the enveloping surface (II); and the affected zone (III).

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The enveloping surface, within which the rocks are greatly deformed, extends up to the surface; the concavity is turned down.

Kegel (German) likens the beds of rock to embedded slabs, which means replacing the vault effect by a lintel effect, with similar results regarding the load at the supports.

Seldenrath and van Iterson (Netherlands) consider the coal-bearing rocks as a pulverulent mass. The influenced zone is limited in every direction by planes of influenced zone, the slope of which depends on the coefficient of friction (fig. 3).

Grond (Netherlands) admits that the enveloping surface of the relaxed rocks has a mixed form; near the working place it is a semiarch, which suddenly changes in appearance and continues along 65° slope (fig. 4).

A complete theory is put forward by Patteisky (German), who is also a specialist on questions of emanation of firedamp. In normal cases, he admits the existence of a pressure arch with front and rear abutments (fig. 5). The advancing of the face causes the front abutment to move, and the span of the arch increases up to a certain limit beyond which dislocation occurs. This brings about formation of an inclined line of break rising above the worked-out zone. It corresponds to the periodical readjustment of the roof that can be observed in faces. A new arch with a reduced span is formed, and the phenomena are repeated. The process as a whole is like that suggested by Grond. When the roof consists of thick, sandy beds, the arch effect is replaced by a slab effect, fulfilling the same role.

The strength of the roof has considerable influence on the general form of the deformations. With a very strong roof subsidence begins far ahead of the coal face and ceases far behind, and subsidence at the face is slight. With a soft roof subsidence begins only a short distance ahead of the coal face and ends a short distance behind it (fig. 6). In both cases, there is a movement of inflexion; this gradually extends upward and causes beds of different strength to separate. This separation has a considerable importance with regard to the migration of firedamp and is illustrated in figure 5.

All these phenomena occur in the roof and floor of the seam. Nevertheless, in the floor these deformations are soon checked by the weight of the rocks. In the roof, on the other hand, they are transmitted right up to the surface.

The study of rock movements is of great importance so far as firedamp emanation is concerned; conversely, the study of firedamp emanation may afford valuable information concerning rock movements. Firedamp is given off at all points where pressure decreases and especially where the rock becomes deformed and relaxes.

The problem is to drain firedamp as near as possible to the point of discharge before it mixes with the ventilation air.

FIREDAMP IN THE SEAM

It is generally agreed in Belgium that firedamp is adsorbed in the coal. The mass of coal shows multiple cracks owing to shrinkage; they indicate that the mass was originally of the same consistency as colloidal gel. This structure is maintained throughout the changes of coalification.

Coal may be considered as a conglomeration of countless micelles with spaces between them forming an infinite number of submicroscopic pores. Thus there is an enormous specific surface favorable to the phenomenon of adsorption.

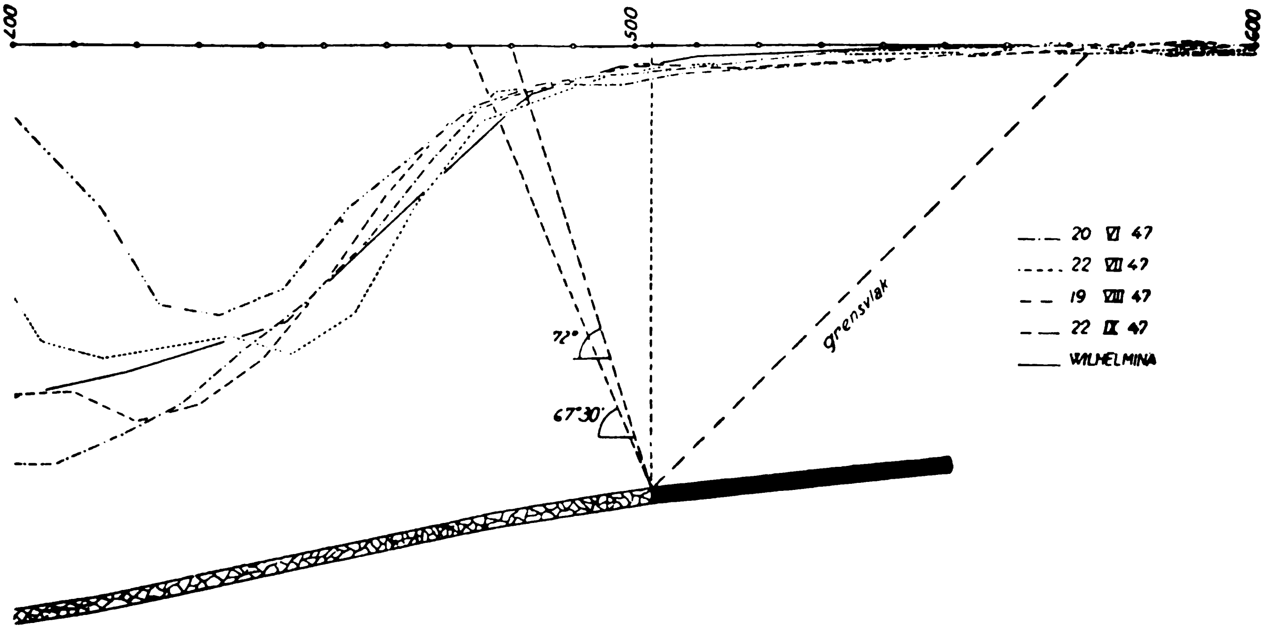
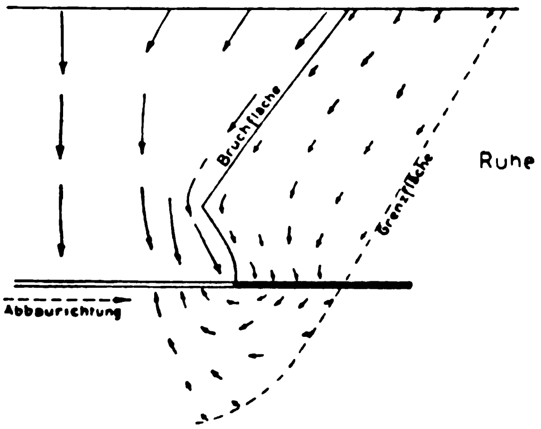


Figure 3. - Limitations of influenced zones of pressure near the working face, according to Seldenroth and van Iterson.



Bruchfläche - plane of break
Grenzfläche - limit plane of break
Ruhe - without influence
Abbaurichtung - direction of working

Figure 4. - Form of the enveloping surface of the pressure-relaxed rocks near the working place, according to Grond.

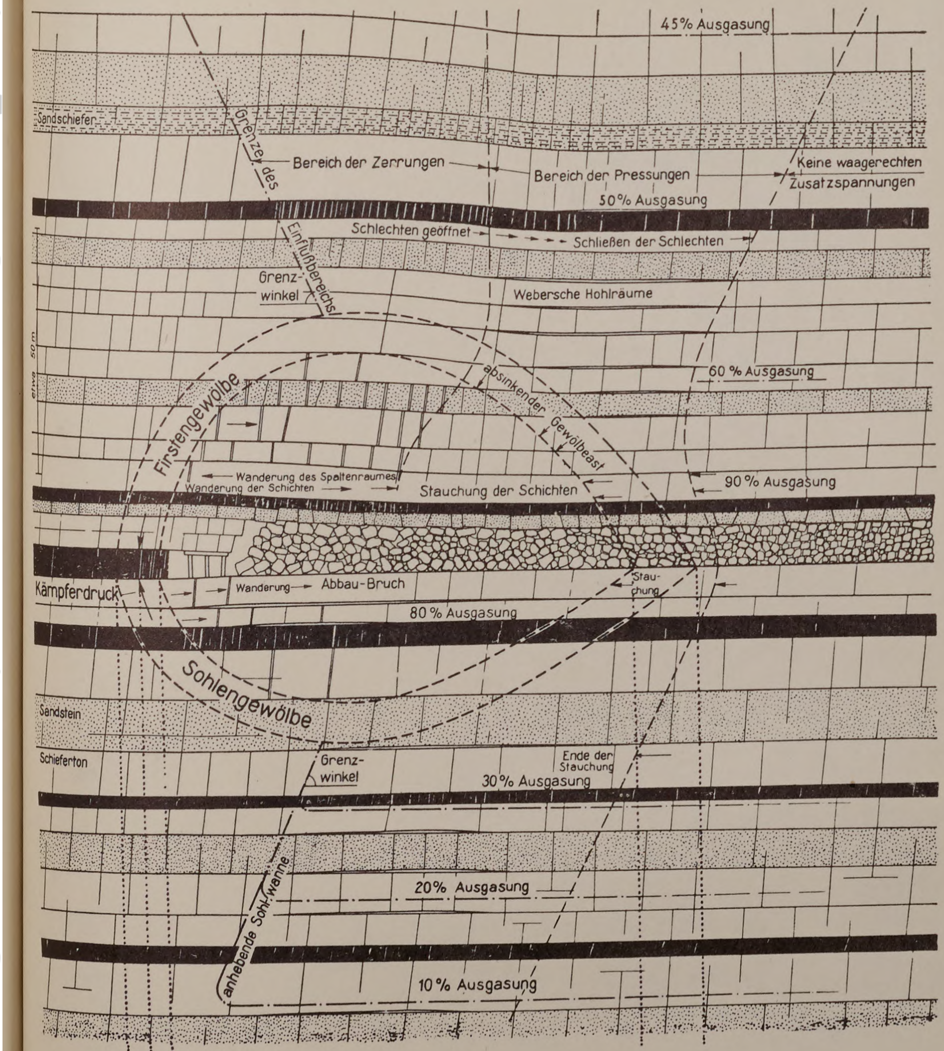


Figure 5. - Illustrating origin theory of Patteisky with respect to rock stresses surrounding an advancing face.

Grenze des Einflussbereichs - limit breakplane
Bereich der Zerrungen - zone of stretch
Bereich der Pressungen - zone of compression
Keine waagerechten Zusatzspannungen - no supplementary horizontal stress
Schlechten geöffnet - opened joints of stratification
Schliessen der Schlechten - shutting of joints
Webersche Höhlraume - Weber's gaps
Firstengewölbe - roof arch
Absinkender Gewölbeast - sinking part of arch
Stauchung der Schichten - driving back of layers
Wanderung der Schichten - displacement of layers
Wanderung der Spaltenräumes - displacement of the zone of opened fissures
Abbau-Bruch - goaf
Ende der Stauchung - End of driving back
Anhebende Sohlwanne - floor arch
Aufspaltung der Schlechten und Gang der Kohle (= Ausgasungsband) - Opening of cleavages and joints, displacement of coal (= degassing strip)
Kämpferdruck - abutment load
Last des Bruches (bezw. Versatzes) und Druck des absinkenden Gewölbeastes - Increasing load on rubbish or packwall, due to sinking centre of arch
Zusammengedrückter Bruch (oder Versatz) - Rubbish or packwall consolidated

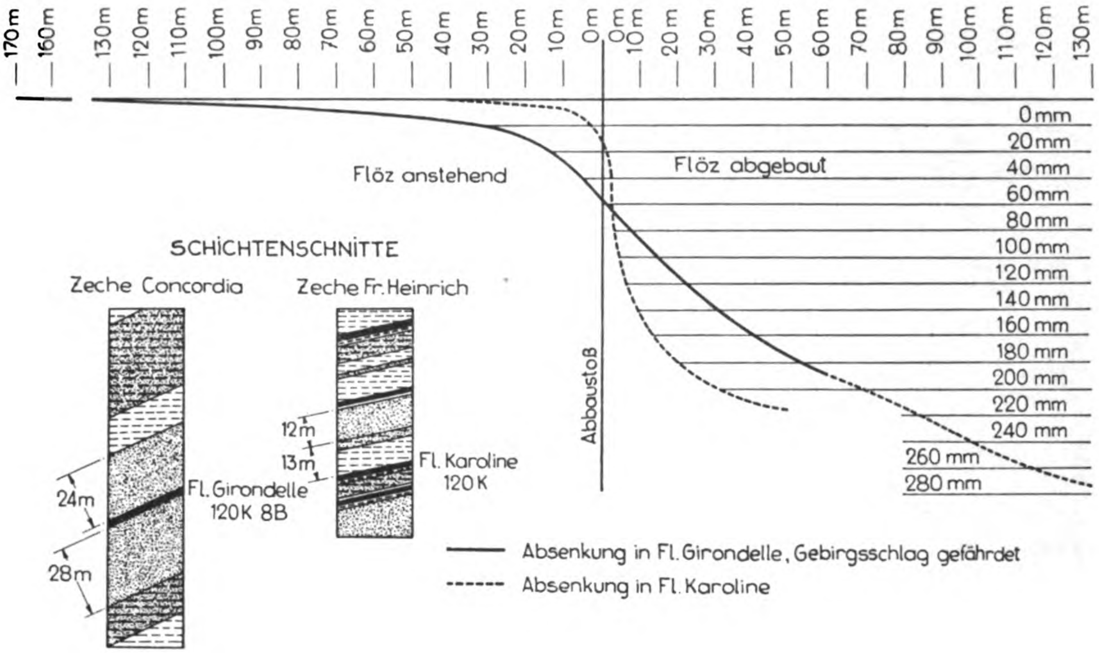


Figure 6. - Subsidence of a soft roof in advance of and behind the face of the coal bed.

Flöz anstehend - seam in place
Flöz abgebaut - goaf
Abbaustoss - face
Schichtenschnitte - section of the rocks
Absenkung in Fl. Girondelle, Gebirgsschlag gefährdet - Subsidence of the roof in the Girondelle seam, subject to roof-bursts

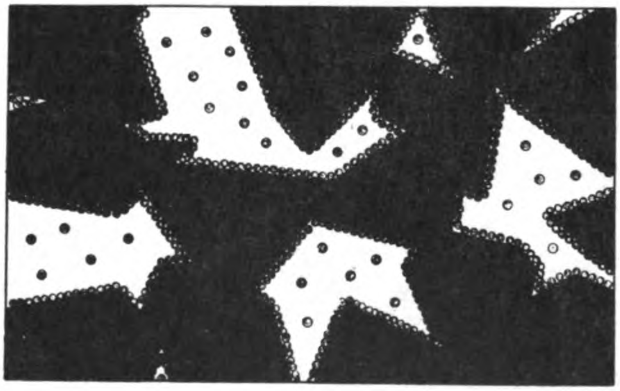


Figure 7. - A hypothetical cross section of submicroscopic dimensions of a piece of coal.

Figure 7 represents a hypothetical cross section of submicroscopic dimensions of a piece of coal. The methane molecules are illustrated by small spheres; some of them cover the surface of the micelles by a process of adsorption, and the others remain as gas in the spaces between the micelles.

These two phases, the adsorption phase and the gas phase, are in equilibrium; there is constant movement of free molecules hitting the wall and becoming adsorbed and of adsorbed molecules evaporating and being set free again.

Various experimenters, notably Coppens, have studied the relationship between coal and methane.

His conclusions are as follows:

(1) One gram of coal previously pulverized and freed from gas can fix 5 to 10 cc. of methane (1 lb. can fix 0.080 to 0.160 cu. ft. methane) measured at normal temperature and pressure. The fixation increases with the degree of evolution of the coals. Anthracite, for example, will fix more methane than bituminous coal. This is to be expected, for the specific surface of coals is an increasing function of their rank. As the colloidal gel contracts, the number of spaces between the micelles increases.

(2) If the temperature rises, adsorption decreases. This also is to be expected, as the increased temperature results in increased speed of the molecules of the gas phase, and consequently fewer molecules will be adsorbed.

(3) If pressure increases, adsorption at first increases in proportion to the pressure, but later to a much more restricted degree, with a maximum of 30 cc. of methane per gram of coal (0.480 cu. ft. per lb.).

This result can be foreseen; the increase in pressure corresponds to a more or less proportionate increase in the number of molecules in the gas phase.

The number of molecules beating against the walls of the micelles also increases in the same proportion and at the beginning gives rise to greater adsorption. Nevertheless, the saturation point is reached as soon as the walls of the micelles are covered with an unbroken layer of molecules. From that moment on, the increase in pressure can no longer cause an increase in adsorption.

(4) The phenomenon of adsorption under pressure is reversible; when pressure decreases the firedamp fixed by the coal is set free again. The phenomenon can be explained easily by the same line of reasoning.

(5) When the gas is drawn off from a block of coal in a vacuum, it can be seen that, after a few days, the emanation diminishes and finally ceases. The coal is therefore apparently completely freed from its firedamp content. If the coal is then broken up and the experiment repeated, it can be seen that firedamp is once more given off; this emission likewise ceases after a few days. Therefore, it may be supposed that degassing occurs only up to a certain distance on the free faces.

In the light of this theory, it is possible to have some idea of the nature of the phenomena that lead to the discharge and drainage of firedamp.

In a virgin rock mass, firedamp is at the pressure of the gas phase. Release of pressure causes expansion and mechanical cracking of the coal. The volume of the spaces between the micelles increases and gas pressure and adsorption decrease. At the same time, the substance is cut in all directions by fissures. In all adjacent intermicellary spaces, the molecules immediately pass from the adsorbed to the gas phase; hence, very great emission of firedamp occurs. This emanation of gas involves a certain thickness of rock, beginning from the planes of fissuration. The net-work of cracks allows the firedamp to flow into the seam over a great distance. The increased permeability observed is a simple mechanical phenomenon.

If relaxation of pressure ceases and the seam is compressed again, the phenomenon likewise ceases. If a second relaxation should crack the seam again fresh fissures are produced, and the phenomenon may be renewed. In practice this is what actually happens.

In his new work on firedamp, Patteisky explains the absence of adsorption in lignite and the increased adsorption in leaner coals. There is, however, a limit that is reached in coals with about 5 to 6 percent volatile content, after which adsorption rapidly decreases.

DRAINAGE TECHNIQUES

In Europe, particularly on the Continent, the most commonly used working method is the longwall method, the faces being completely worked out, then stowed or caved. On the Continent, faces generally follow the slope of the seam. As they advance 2 horizontal galleries are driven, 1 at the top and 1 at the bottom, the latter being used as the air intake and to transport the coal and the former for the air outlet.

The relaxed zone extends above and below the seam being worked. It is in this zone that firedamp drainage must be undertaken, and various methods are used, as follows:

Cross-Measures Boreholes Method From Working Galleries

This method, the most commonly used, includes several variations:

(1) Boreholes inclined at a small angle to the horizontal above the seam and drilled forward in the roof from the top gate very close to the face. These holes are marked I in figure 8. They are designed to drain some of the firedamp from the seam that is being worked and from bands of coal in the lower roof.

The boreholes pass through the beds in the lower roof in a high-pressure zone that precedes the face. The firedamp emanating from the seam near this strongly compressed cracked band probably migrates through cracks parallel to the face toward the boreholes (fig. 9).

(2) Long boreholes, marked II in figure 8, sloping at an angle of 55° or 70° to the horizontal and drilled at right angles to the line of the roadway.

(3) Boreholes drilled downward a short distance from the faces and marked III in figure 8. They are drilled in the same direction as the first network (that is, forward and downward) and are at an angle of 60° to the horizontal.

The pressure of the firedamp is higher here than in the holes bored upward. The holes remain more gastight. This drainage technique has not yet been greatly developed because the drilling of long downward holes of large diameter still presents some difficulty, especially in hard rocks.

(4) Besides the holes drilled from the top gate road, a network of holes can be drilled from the bottom gate. This technique is regularly applied in a colliery in Germany. At first sight, it seems especially suitable for long faces. However,

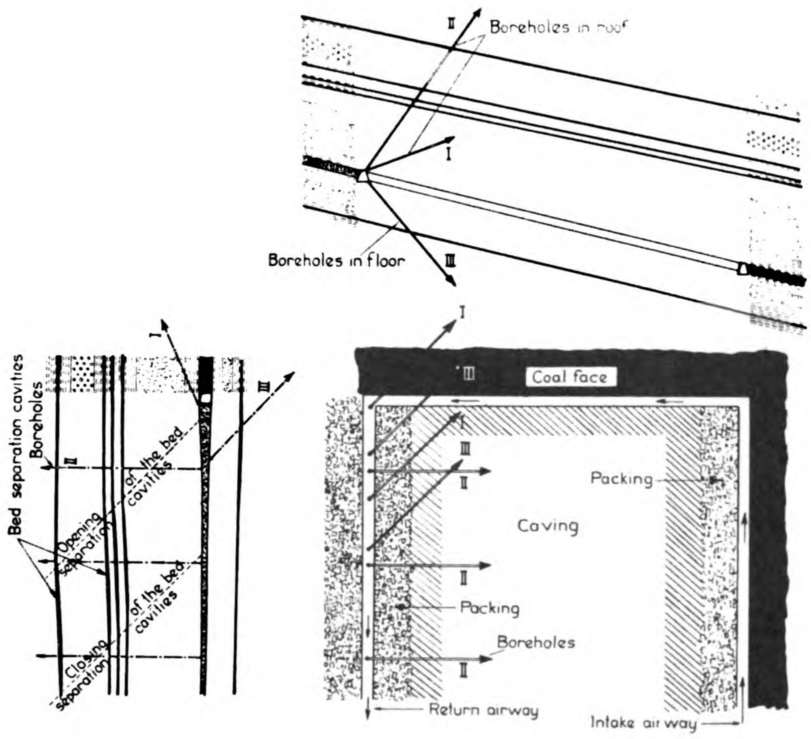


Figure 8. - Inclined bore holes for draining methane from the seam being worked and from bands of coal in the lower roof.

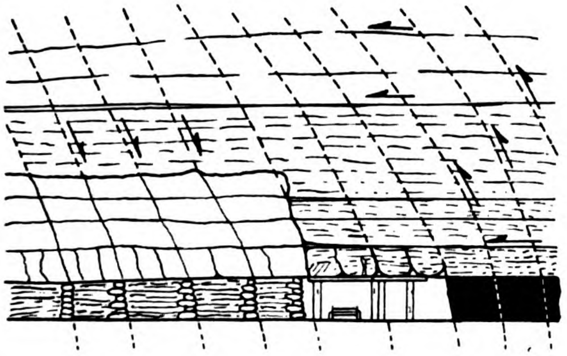


Figure 9. - Migration of methane through cracks parallel to the face toward the boreholes.

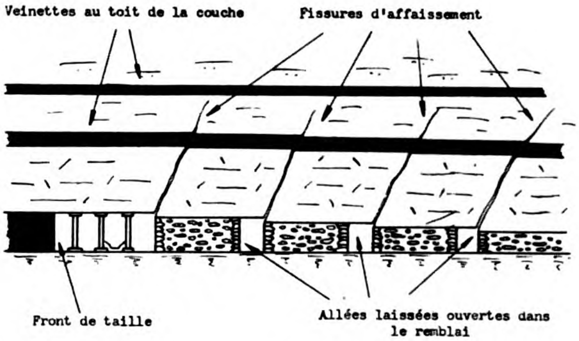

Veinettes au toit de la couche
Fissures d'affaissement
Front de taille
Allées laissées ouvertes dans le remblai

Figure 10. - Cracking of the roof in the Röschen (pack-cavity) method for draining methane.

Veinettes au toit de la couche	bands of coal in roof
Fissures d'affaissement	cracks due to subsidence
Front de taille	coal face
Allées laissées ouvertes dans le remblai	cavities remaining in goaf

from experiments in Belgium at the Limbourg-Meuse colliery and in Great Britain, it can be seen that firedamp drained from the roof by the bottom gallery causes the quantity drained by the top gallery to decrease. Furthermore, the output and purity of the gas drained through the boreholes in the bottom gallery quickly deteriorate. This confirms the existence of bed-separation cavities in the roof, which form communications parallel to the face over the entire length of the latter and enable the whole of the relaxed zone to be drained through the boreholes in the top gate.

(5) Boreholes drilled downward from the working roadways, as at Point of Ayr colliery in Great Britain.

Boreholes Drilled From Roads Outside Seam Being Worked

There are two types:

(1) Holes are drilled downward from a network of roads about 100 meters (328 feet) above the seam, and they end about 20 meters (66 feet) above the roof of the seam. This method is used in Lorraine.

(2) Headings are driven in a seam or band of coal beneath the seam being worked, with boreholes drilled upward through the rocks above the seam. This method is being tried out in the Netherlands.

These methods make it possible to have the gas pipes in roadways outside the seam being worked. The gastightness of the boreholes is easier to maintain because the mouth of the hole is situated outside the severely fractured zone in the immediate vicinity of the face. On the other hand, enough time must be available for carrying out all this preparatory work before mining is begun. The characteristics common to all borehole methods are that a fairly pure firedamp is produced and the control and maintenance of the boreholes are easy. Borehole methods are sure and accurate; however, they must be carried out very carefully. In certain hard rocks, particularly heterogeneous rocks, the problem of drilling has not yet been completely solved.

Superjacent Heading Method

Before any working is begun, headings are driven in a seam or band of coal above the seam to be worked. These headings are drainage galleries for the firedamp discharged by rocks deformed by working. They are sealed by brick walls through which the firedamp is drawn by suction. This technique is advantageous since all the preparatory work for drainage is done outside the working area. The firedamp obtained is generally rather impure. There is a risk of air infiltrating, and the gastightness of the seals is difficult to maintain when they are situated, as is often the case, in an influenced zone.

This method is frequently employed in the Saar.

Drainage of Firedamp From Gob by Suction

This is a variation of the previous method, in which the drainage galleries are worked-out areas. It is used in French collieries in the Bassin du Nord et du Pas-de-Calais.

Röschen (Pack-Cavity Method)

This method involves leaving cavities in the packing of the seam being worked; the roof cracks at right angles to these cavities, aiding discharge of firedamp (fig. 10). The distance between these cavities is generally between 10 and 15 meters

(32.8 and 49.2 feet). The ends of the cavities are sealed by packs in which the gas pipes are placed. When the percentage of CH_4 in the gas is too low, the cavity is abandoned and isolated by gastight seals. Generally 4 to 6 cavities are in use simultaneously.

The method is used in the Saar at Reden, König, and Frankenholz collieries.

Drainage by Blowers

Boreholes are drilled toward the fault or break that feeds the blower, which is subjected to strong suction to prevent the gas from escaping towards the working place through the cracks in the rocks.

This method was used in a heading in the Louisenthal colliery in the Saar.

DRILLING APPARATUS AND DRAINAGE PIPES

The introduction of the borehole method required new apparatus for drilling into the rock. The Fortschritt P_4 VI drill, made in Germany by the Nüsse und Gräfer firm, enables boreholes of large diameter (80 to 115 mm. or 3.15 and 4.53 inches, to be drilled rapidly and economically in the rocks over lengths of up to about 100 meters (328 feet). The entire drilling apparatus weighs 415 kg. (915 lb.); since it is small in size and weight, it can easily be transported and set up in all underground workings. Holes can be bored in most galleries without any previous preparation whatsoever, and only two men are required to work the machine (fig. 11).

The bit is vitally important in drilling. Many models are now available for the various rocks to be drilled.

Immediately after a borehole is drilled, a pipe about 10 meters (33 feet) long is fitted into it and plays an important part in keeping the system gastight. Leakages are disastrous; they give rise to penetration of air or leakage of firedamp, depending on whether there is underpressure or pressure.

Figure 12 illustrates the different stages of the drilling of a borehole before it is put into use. It shows the actual borehole, with a diameter of 80-65 mm. (3.15-2.56 inches), the reaming over a length of 10.50 meters (34.45 feet) and with a diameter of 115 mm. (4.53 inches), and the fitted pipe 80 mm. (3.15 inches) in diameter and about 10 meters (33 feet) long, and lastly the water-trap device at the bottom of the borehole. When the borehole passes through slaty rocks, it is advisable to install a water and stone trap. Figure 12 also shows the connection of a borehole to the mains and pictures the water and stone trap, flexible hose, isolating valve, tap for taking samples, and diaphragm for measuring output.

The main pipe has no special characteristics of its own; the diameters used so far vary between 150 and 300 mm. (5.9 and 11.8 inches). It is important to have a good water trap since water always condenses even in very dry rocks. It is drained by the very simple means illustrated in the diagram.

Quite recently, a new system was tried in the Hansa mine, which eliminated the necessity for spraying the cement to seal the pipe (fig. 13). Rubber rings are fitted to the top of a drainage pipe 10 meters (33 feet) long, which can be fitted tightly into the ground by compression with a holddown nut at the top of the pipe.

All borehole methods produce fairly pure firedamp and allow regular control and maintenance of each hole.

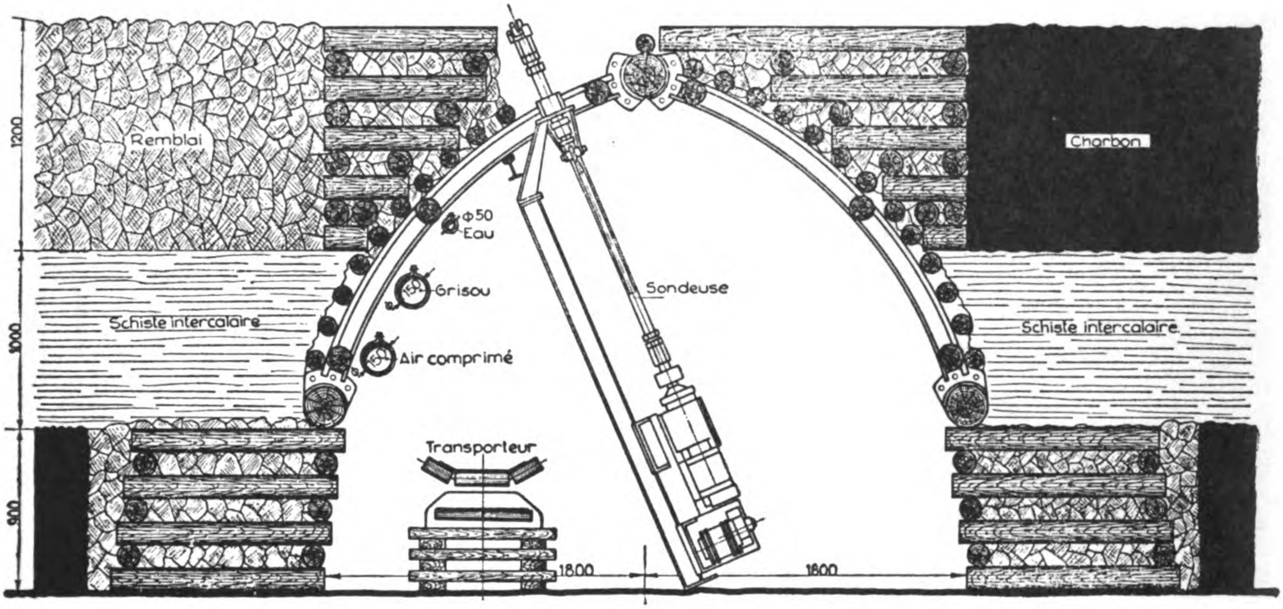
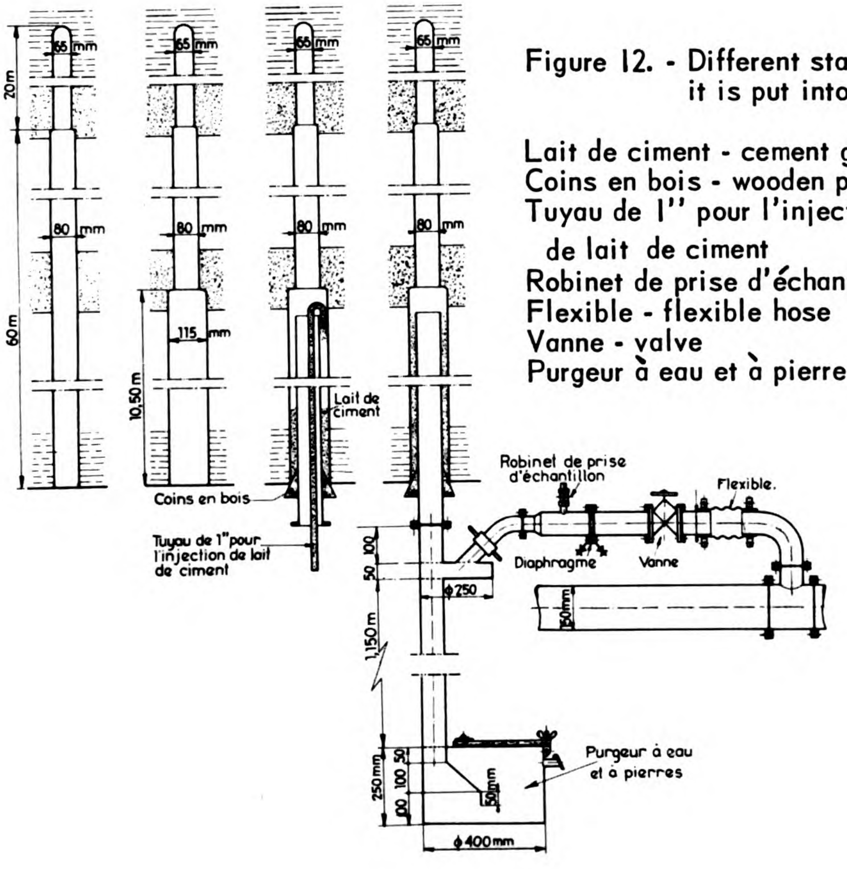


Figure 11. - Nüsse and Gräfer machine for drilling large-diameter boreholes rapidly.

Remblai - packing
Schiste intercalaire - shale
Eau - water
Grisou - firedamp
Air comprimé - compressed air
Sondeuse - drill machine
Transporteur - conveyor
Charbon - coal

Figure 12. - Different stages of drilling a borehole before it is put into use.

Lait de ciment - cement grout
Coins en bois - wooden plugs
Tuyau de 1" pour l'injection de lait de ciment - 1 mm. (0.04 inches) pipe for injection of cement grout
Robinet de prise d'échantillon - sampling valve
Flexible - flexible hose
Vanne - valve
Purgeur à eau et à pierre - water and stone trap



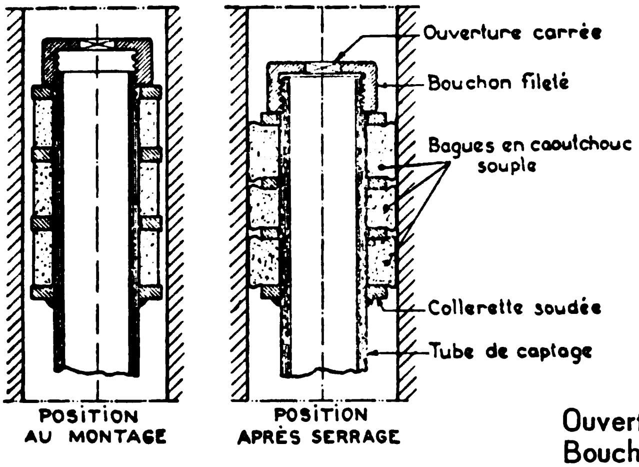


Figure 13. - Method of sealing pipe used in Hansa mine.

Ouverture carrée - square opening
Bouchon fileté - screw-plug
Bagues en caoutchouc souple - flexible rubber rings
Collerette soudée - welded flange
Tube de captage - drainage tube
Position au montage - position when set up
Position après serrage - position after screwing down

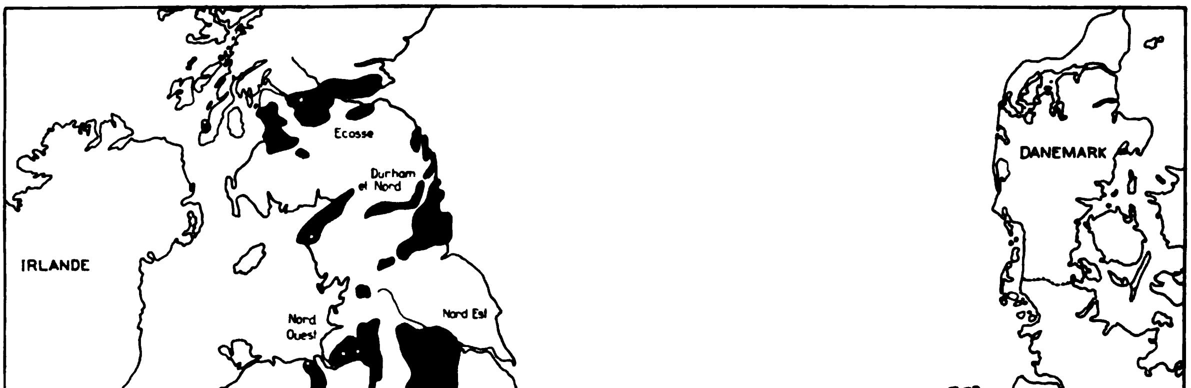


Figure 14. - Main coal basins of western Europe and Great Britain. Collieries draining firedamp shown by white dots.

The quality and quantity of the mixture collected from each of the boreholes are checked, and the underpressure applied is measured. The percentage of CH_4 in the mixture gives clear indications concerning the gastightness. There are different ways to determine this:

(1) By analyzing at the surface samples taken in bottles underground. This method is accurate but slow, and does not allow the underpressure at the orifice of the hole to be regulated immediately.

(2) By measuring the density of the mixture at the orifice of each borehole. Portable Junders or Bunsen-Schilling densimeters are used for this purpose. A fraction of the mixture is driven into the apparatus with an injector. The rate of flow of a given quantity of gas through a stainless steel diaphragm is then measured. A graph immediately reveals the density of the gas in relation to the air, which is a function of its percentage of CH_4.

These devices must be handled delicately because the gauged orifices easily become blocked up;

(3) By measuring the percentage of oxygen. Today the Fyrite oxygen indicator is used. This is a small, light apparatus, easy to handle that gives indications that are accurate enough to control the underpressure at the orifice of the borehole immediately, so as to maintain a high percentage of CH_4.

Checking the quantity of gas given off at each borehole is not so essential but can provide useful information.

A diaphragm is fixed permanently in the mainpipe at the orifice of the boreholes to measure pressure, and difference in pressure is measured by an inclined differential manometer.

A German firm (P. Gothe of Bochum) has just produced an accurate portable apparatus, the Luga Stromungsmeter, which shows the speed of the gas current and hence the output. This apparatus makes it possible to do away with the diaphragms, which choke the pipes; there is a vast field of measurement, and this is absolutely essential, as the output varies considerably from one borehole to another.

DRAINAGE OF FIREDAMP IN DIFFERENT COUNTRIES

The aforementioned theoretical research and experiments carried out in Germany during and before the war should have led to a rational drainage method. However, this first came into being purely by chance in 1943.3/ Owing to certain modifications in the mining plants in the Mansfeld colliery in the Ruhr, it was necessary to begin work in a part of the Rottgersbank I seam, near an upward borehole 280 mm. (11 inches) in diameter, which was drilled through a group of unworked gassy seams.

Working was begun during the first quarter of 1943, almost below the borehole in question. After a few weeks it was noticed that firedamp was flowing out of the borehole. The hole was stopped with wooden wedges, but the firedamp continued to escape with a whistling sound, which indicated relatively high pressure. A pipe 2.5 meters (8.2 feet) long was then cemented into the hole, and connected with a pipe that evacuated the firedamp toward the return airshaft; the output reached about 16,000 cu. m. (564,960 cu. ft.) per day. The first firedamp drainage had been achieved.

3/ Firedamp was used for heating in an English mine 2 centuries ago; in the Saar also blowers have been drained and the firedamp put into use. In Belgium, the Paturages testing station has been supplied with firedamp from an unused mine, for more than 40 years.

This phenomenon fully confirmed the investigations carried out some time before by Forstmann and Schulz. The pressure decline caused by working in the Röttgersbank I seam gave rise to an emission of firedamp that flowed toward the borehole. The management decided to drain it systematically by drilling new boreholes as the faces advanced. This drainage was carried out from April 1, 1943, to November 20, 1944, and provided a total of 5,600,000 cu. m. (197,758,000 cu. ft.) of pure methane.

Drainage was then practised in the Hansa mine, where the first experiments, undertaken in 1944, were abandoned owing to the war but resumed in 1947.

The Germans developed an apparatus enabling boreholes to be drilled rapidly and economically, an essential condition for the borehole-drainage method.

In 1948 drainage was begun at Hirschbach colliery in the Saar, on the initiative of Vidal (engineer), who must also be considered a pioneer in this work. He achieved this first drainage by the simplest means, without boreholes, with two drainage galleries driven in the seam immediately above the seam being worked. The results were highly satisfactory and 11 million cu. m. (388,454,000 cu. ft.) of pure methane were produced in 2-1/2 years.

In 1949 Belgium began work in its turn, using virtually only one technique, that of upward boreholes drilled from the top gate road to the working face. Lorraine followed, with downward boreholes outside the working area at St. Charles colliery; Great Britain, with boreholes in the floor at Point of Ayr colliery in North Wales; the coal mines of northern Franch with drainage in the wastes above a worked-out area in Liévin colliery, pit No. 4; and lastly, in 1951 in Netherlands at Emma colliery, State mines with upward boreholes outside the working area.

Figure 14 shows the main coal basins of Western Europe, with the collieries draining firedamp shown by white dots.

Figure 15 gives the number of collieries per year per country draining firedamp in Germany, the Saar, Belgium, Great Britain, France (with a division between the Northern basin and the Lorraine basin), and Netherlands.

Figure 16 gives the total drainage of firedamp per year in all these countries combined.

Drainage of Firedamp in Germany

By the end of 1951, 12 collieries in the Ruhr and 2 collieries in the Aix-la-Chapelle Basin were draining firedamp. Except for the Emscher-Lippe mine, all adopted the crossmeasure hole method.

Figure 17 shows the areas in the Ruhr that are drained.

Figure 18 gives a diagram showing the amount of firedamp drained off in each colliery per month. It includes all the firedamp removed from the workings, that is, firedamp drained off into pipes and dispersed underground in the ventilating air, firedamp brought in pipes to the surface and dispersed into the air, and firedamp used.

The following table shows the output of coal and firedamp per colliery and the relationship between these figures.

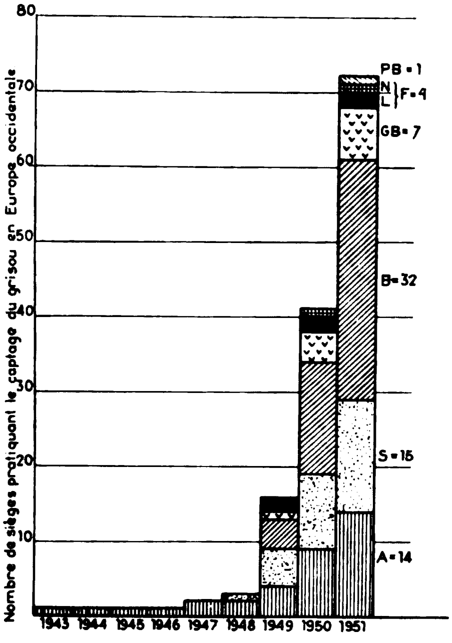


Figure 15. - Number of collieries per year per country draining firedamp.

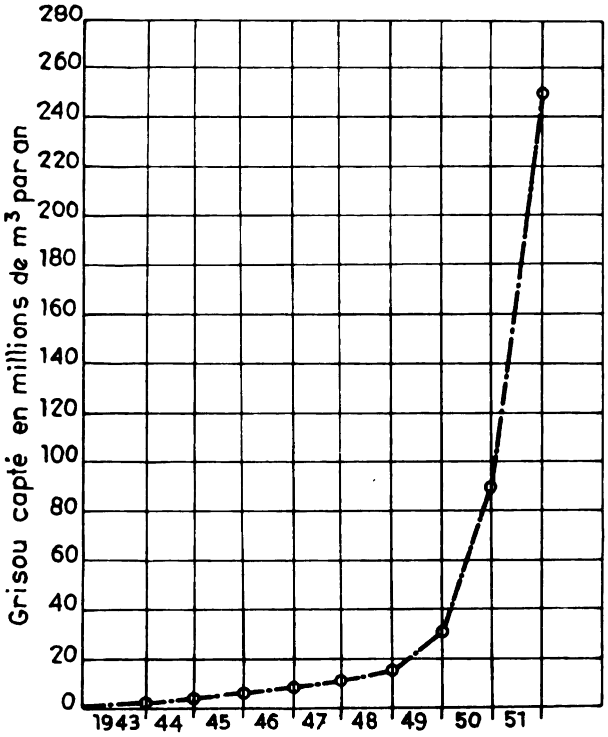


Figure 16. - Total combined drainage of firedamp for all these countries.

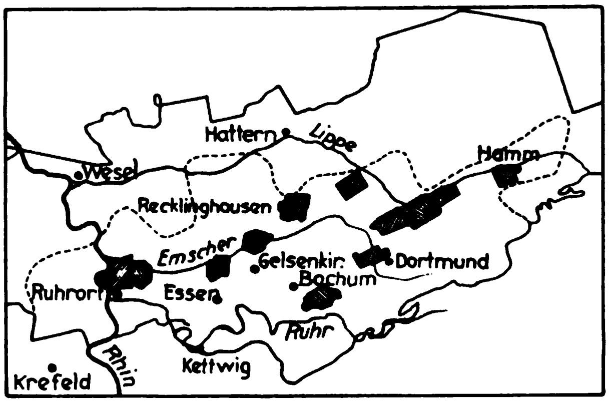


Figure 17. - Areas in the Ruhr that are drained.

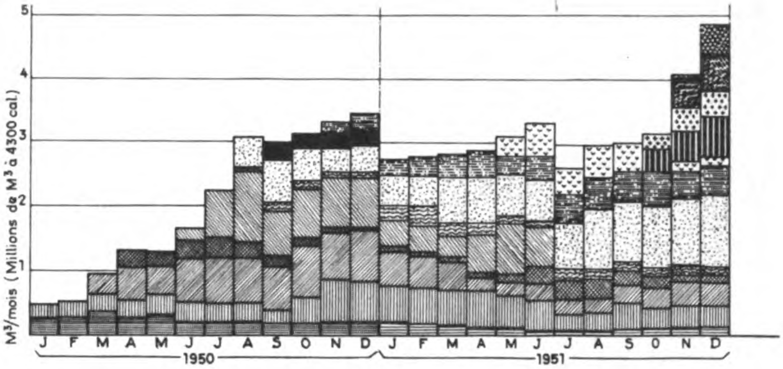


Figure 18. - Amount of firedamp drained in each colliery per month.

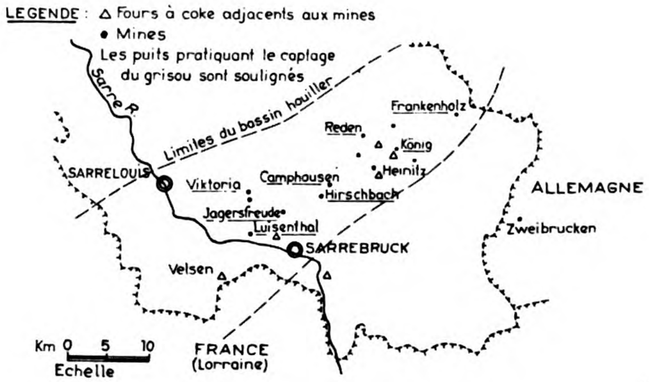


Figure 19. - Mines draining firedamp in the Saar.

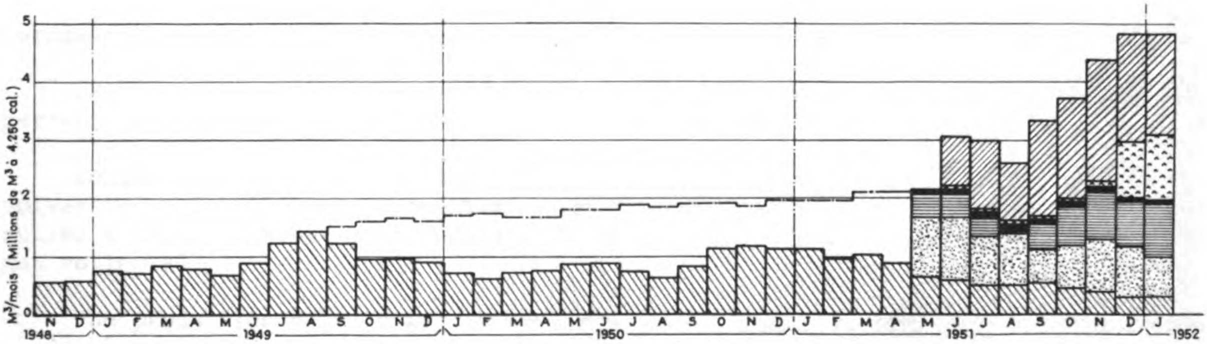


Figure 20. - Production of firedamp, per month, in six collieries in the Saar that use the gas.

	Daily output, tons		Methane drained per day		CH$_4$ drained per ton of coal mined	
Collieries	Metric (2,204.6 lb.)	Short (2,000 lb.)	Cu. m.	Cu. ft.	Cu. m. per metric ton	Cu.ft.per short ton
Mansfeld............	1,800	1,984	4,500	158,900	2.50	80.1
Hansa................	2,600	2,866	5,000	176,600	1.91	61.6
Haus Aden...........	1,980	2,182	6,000	211,900	3.03	97.1
Emscher-Lippe.......	3,240	3,572	2,620	92,520	.80	25.9
Carl Alexander......	1,940	2,138	2,500	88,290	1.29	41.3
Victoria-Lünen......	3,280	3,616	11,350	400,810	3.46	110.8
Neumühl.............	3,450	3,803	6,900	243,670	2.00	64.1
Minister Achenbach..	3,309	3,648	2,500	88,290	.75	24.2
General Blumenthal..	3,360	3,704	9,160	323,480	2.73	87.3
Maria EBV...........	1,680	1,852	6,340	223,890	3.77	120.9
Fr. Thyssen 2/5.....	3,840	4,233	13,200	466,140	3.46	110.1
Graf Bismarck 1/4...	2,165	2,387	5,750	203,060	2.66	85.1
Heinrich Robert.....	4,520	4,982	13,400	473,210	2.97	95.0
				Average	2.40	77.2

Anticipated Future Output

The daily output of the Ruhr and Aix-la-Chapelle Basins is 400,000 metric tons (440,800 short tons). The D.K.B.L. expects to drain 1 million cu. m. (35,310,000 cu. ft.) of CH$_4$ per day, that is, 2.5 cu. m. (2,825,000 cu. ft.) per ton (80 cu. ft. per short ton) for the basin as a whole, the present day average of the collieries engaged on drainage.

By the end of 1951, 80,000 cu. m. per day was being drained; when the Grillo Grimberg and Heinrich Robert installations were recently put into service, about 100,000 cu. m. (3,531,000 cu. ft.) per day was reached.

The gas is used:

(1) To heat boilers. This does not require much equipment; all that is needed is suitable burners. The percentage of CH$_4$ in the gas may fall as low as 25 to 30. At present that is the most common proportion in Germany.

(2) As domestic-consumer gas. In this case, it is delivered unchanged to the Ferngas mains. It must contain over 50 percent CH$_4$.

(3) As motor fuel. The gas is compressed at 300 atmospheres; gas with over 80 percent CH$_4$ is required.

Schulz considers that a single isolated mine cannot produce such gas, for it involves very high initial expenditure (compressors, gas holder, gas bottles) and requires a certain amount of regularity of output and of the percentage of CH$_4$ in the gas collected.

The production of such gas is very remunerative when several sources of gas are available situated close together with a central station. Production is planned in the east of the Ruhr, in the Kamen Hamm region, where 5 or 6 collieries over a distance of 30 km. (18.6 miles) produced about 1 million cu. m. (35,310,000 cu. ft.) of CH$_4$ per month throughout 1951. Other collieries in the area will soon be equipped, and it is expected that a compression station with a capacity of 2 million cu. m. (70,620,000 cu. ft.) of CH$_4$ per month will be built.

Drainage of Firedamp in the Saar

By January 1952, 15 collieries out of 18 were draining firedamp, and 6 collieries were preparing a drainage system. Various methods of drainage are used, and the percentage of CH_4 in the gas varies considerably. Figure 19 shows which pits are engaged on firedamp drainage.

In 10 collieries the percentage of CH_4 is less than 60. It is over 80 percent in 3 collieries, namely Hirschbach, Minna I, and Louisenthal.

The methods used are:

(1) Crossmeasure hole method.
(2) Superjacent heading method.
(3) Röschen (pack-cavity method).
(4) Drainage from worked-out areas.
(5) Drainage from blowers.

In the Saar and Lorraine beds of very hard heterogenous conglomerates in the coal-bearing rocks constitute an obstacle to the systematic application of the cross-measure borehole method. Attempts are being made to solve this problem by using diamond boring crowns, and the results are encouraging.

Uses of Gas Drained

The 6 collieries using the gas produce 73,000 cu. m. (2,578,000 cu. ft.) CH_4 per day. The diagram in figure 20 shows the production per colliery per month. For certain months it gives only the aggregate production.

Figure 21 shows the total monthly amount of firedamp drained at all the collieries put together, subdivided into firedamp removed from the workings, brought to the surface, and put to use:

(1) The gas is used mainly to heat coke ovens, thus saving about 40,000 cu. m. (1,412,600 cu. ft.) of domestic gas per day.

(2) In several mines firedamp is used to heat boilers. For this purpose the purity of the gas is less important.

(3) Gas rich in methane is compressed into bottles and used as motor fuel. At present there are 3 compression and bottle-filling stations, using a pressure of 250 kg. per sq. c. (3,556 lb. per sq. in.). This fuel costs about half the price of gasoline and allows the vehicles to cover a distance of 100 to 120 km. (62 to 75 miles) at each filling. The gas is sold at a very remunerative price.

(4) Firedamp also is used as fuel for driving the feeder compressors of the domestic gas mains of the Saar and Lorraine Basins. The Burbach compression station near Louisenthal consumes 9,500 cu. m. (335,480 cu. ft.) of methane every day for this purpose.

(5) Firedamp also is diverted to some extent into the Ferngas mains and mixed with domestic gas.

Drainage of Firedamp in Great Britain

Firedamp was being drained from an English coal mine through pipes and used for heating as far back as 1746.

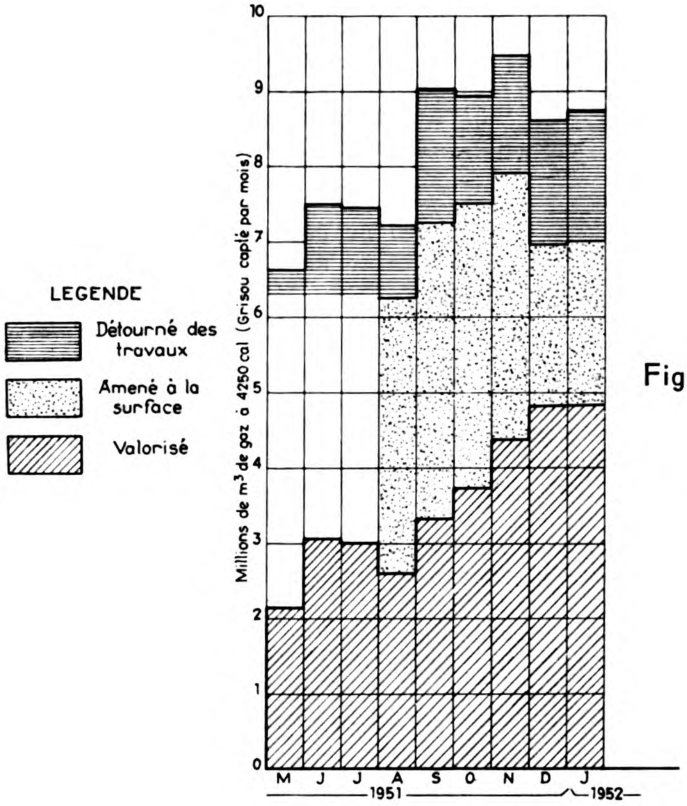


Figure 21. - Combined total amount of firedamp drained per month from all collieries, subdivided into firedamp removed from workings, brought to surface, and put to use.

Détourné des travaux - removed from the workings
Amené à la surface - brought to the surface
Valorisé - put to use
Millions de m^3 de gaz à 4250 cal (Grisou capté par mois) - millions of m^3 of gas of 4250 calories (firedamp drained per month)

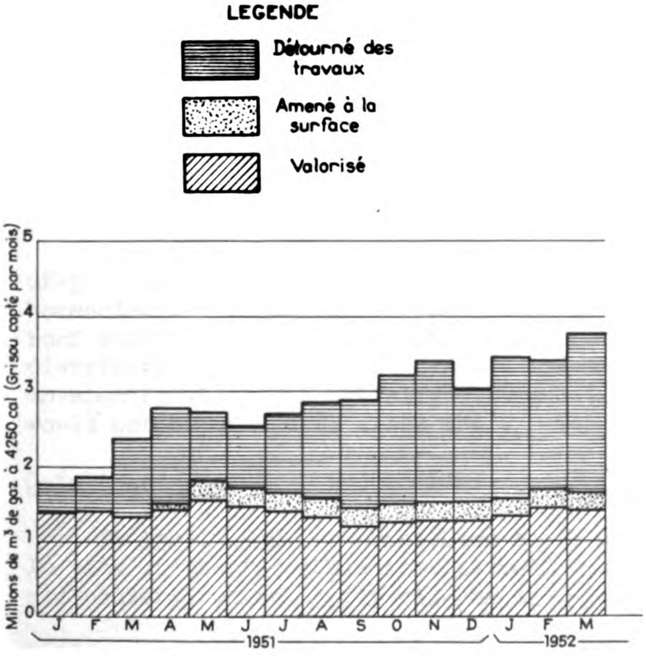


Figure 22. - Total amount of firedamp drained per month from all collieries in Great Britain.

More recently (in May 1950) Great Britain tackled the problem by sending a delegation of engineers appointed by the Ministry of Fuel and Power and the National Coal Board to visit drainage installations in Germany, Belgium, and the Saar. A second delegation visited Belgium in 1951.

The first delegation published a detailed report giving an account of knowledge of the subject gained so far on the Continent, and systematic experiments were undertaken in nine British mines. These mines are situated in five different divisions (Scottish, Northern, Northwestern, West Midlands, and Southwestern) and are mainly near the west coast.

In all the experiments the crossmeasure hole method was used. The aim of the experiments was to find out the possibilities of the new technique in different kinds of seams and to discover the influence on gas output of various parameters, such as diameter, length, and position of the boreholes, rate of advance of the coalface, variations in barometric pressure, etc.

The present situation is as follows: Firedamp is being drained at 13 pits. Encouraging results have been obtained at 10, and at 5 of these the firedamp has already been brought to the surface. Plans are in hand to lay underground and shaft gas mains at four more pits. Firedamp drainage trials are to be begun shortly at 4 collieries in addition to the 13 pits in question.

The diagram in figure 22 shows the total amount drained in all the collieries per month.

Drainage at Point of Ayr Colliery (Northwestern Division)

Point of Ayr colliery is situated very close to the Irish Sea near the town of Prestatyn, North Wales. The workings extend under the estuary of the River Dee.

The coal-bearing rocks are covered with about 20 meters (65.6 feet) of cap rocks, consisting of gravel, sand, and especially clay, which forms avvery watertight layer. The first seam lies at a depth of 85 meters (279 feet). The seams, although at shallow depth, are very gassy, probably owing to the impermeable covering that prevents the firedamp from escaping.

Mining is by room-and-pillar. About 50 percent of the coal is left unworked to prevent rock movement and protect the workings against any infiltrations of sea water.

Only firedamp drainage using boreholes drilled downward in the floor gives outstanding results here. The output equals that of the best achievements with boreholes drilled upward.

In this case, the discharge of firedamp cannot be explained by the relaxation-of-pressure theory. The remaining pillars represent 50 percent of the coal, and the boreholes are situated far behind the faces. There is no apparent convergence of roof and floor. Some English authors suppose that this method of working causes redistribution of the loads borne by the lower seams, giving rise to disturbances and movements, which, though slight, might increase the permeability of the seam but would not be enough to crack the superincumbent rocks.

Output and Use

In April 1950 two Lancashire boilers were equipped for heating with firedamp. In view of the favorable results obtained and the ever-increasing output of firedamp, six boilers, which supply all the energy required in the mine, were equipped.

In August 1950, 11,500 cu. m. (406,000 cu.ft.) of pure firedamp per day were being obtained, and in June 1951 the output rose to 27,000 cu. m. (953,500 cu. ft.) per day with 14 boreholes. The present output is higher than the amount required for the boilers; the excess is blown into the atmosphere.

There is no exhauster. The natural pressure in the pipes underground varies between 1 and 1.5 kg. per sq. cm. (14.22 and 21.33 lb. per sq. in.); it is reduced on the surface to 0.5 kg. per sq. cm. (7.11 lb. per sq. in.) by a pressure reducer.

Drainage of Firedamp in France

Colliery No. 4 of the Liévin group has been engaged on firedamp drainage since January 1950. A retreating face led to the drainage of firedamp in the gob of a seam lying about 12 meters (39.4 feet) immediately above. This produced 8,000 cu. m. (282,500 cu. ft.) of pure methane per day, the mixture of air and firedamp arriving at the surface with about 60 percent methane.

In Lorraine three collieries - St. Charles, Ste. Fontaine, and Faulquemont - are regularly engaged on firedamp drainage by the superjacent heading method or by boreholes drilled upward from a worked-out area. Present production is 70,000 cu. m. (2,472,000 cu. ft.) per day of pure firedamp, which corresponds to 12.5 percent of the total amount of firedamp extracted from the basin. This high proportion must be emphasized.

Drainage of Firedamp in Netherlands Limburg

None of the mines in Netherlands Limburg is very gassy. Nevertheless, two mines, Emma and Hendrik, where bituminous coal is mined, have fairly abundant discharges of firedamp.

Since March 1952 Emma mine has been draining firedamp and bringing it to the surface in pipes. The output of gas is still very low (1,000 cu. m. (35,310 cu. ft.) of gas with 30 percent CH_4 per day).

Hendrik mine is also interested in firedamp drainage, and work is now being undertaken. It is hoped to bring the firedamp to the surface in pipes shortly.

Drainage of Firedamp in Belgium

In Belgium firedamp is drained by the single method of boreholes drilled from the roadways, which makes it possible to place all the installations in return airways. Generally, only long upward holes are drilled, perpendicular to the roadway.

Despite the highly satisfactory results obtained in Belgium, which leads the way as far as firedamp drainage is concerned (firedamp is being drained in 32 collieries and put to use in 16), considerable improvement could still be made by systematic research, especially into downward boreholes and short, sharply inclined boreholes. In some mines control is organized to perfection, but methods should be further developed.

At the beginning of 1952, in collieries in the Hainaut Basins, where the firedamp obtained is put to use, the monthly output was 3,800,000 cu. m. (134,200,000 cu. ft.) of CH_4 for a coal output of 200,000 metric tons (220,500 short tons).[4]

The following table shows the firedamp drained in each colliery per metric ton of coal mined in the colliery as a whole. The average is 19 cu. m. per metric ton (609 cu. ft. per short ton), with a very high maximum of 73.58 cu. m. per metric ton (2,358 cu. ft. per short ton).

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[4] In October 1952 the output reached 4,500,000 cu. m. (158,913,000 cu. ft.), the calorific value being 8,500 calories per cu. m. (955 B.t.u. per cu. ft.).

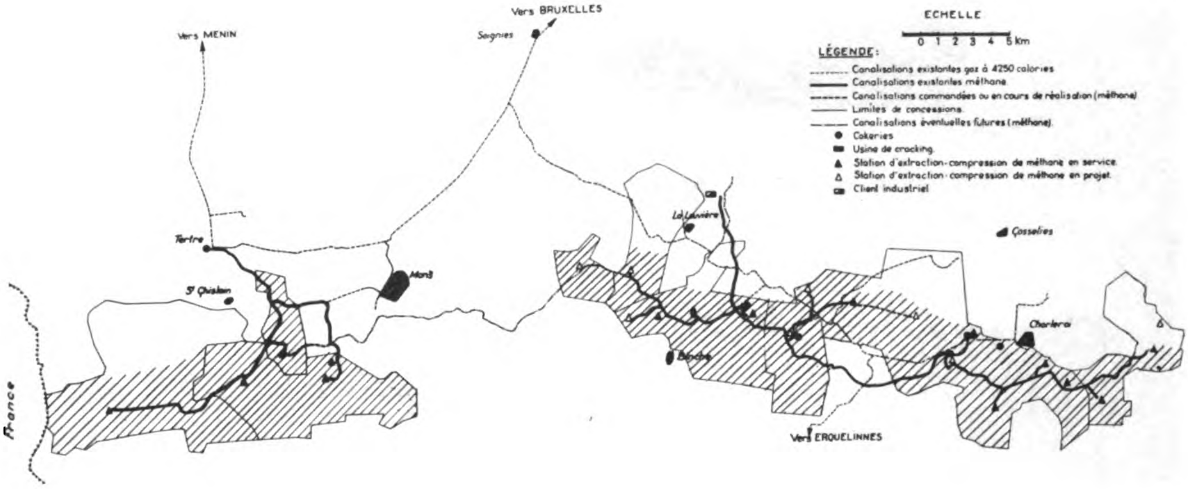
Vers BRUXELLES
Soignies
Vers MENIN
ECHELLE
0 1 2 3 4 5 Km
LÉGENDE:
Canalisations existantes gaz à 4250 calories
Canalisations existantes méthane
Canalisations commandées ou en cours de réalisation (méthane)
Limites de concessions
Canalisations éventuelles futures (méthane)
Cokeries
Usine de cracking
Station d'extraction-compression de méthane en service
Station d'extraction-compression de méthane en projet
Client industriel
Tertre
St Ghislain
Mons
La Louvière
Gosselies
Charleroi
Binche
Vers ERQUELINNES
France

Figure 23. - Coal fields and collieries in Belgium where firedamp is drained; also coking and cracking plants, firedamp and ordinary gas mains, etc.

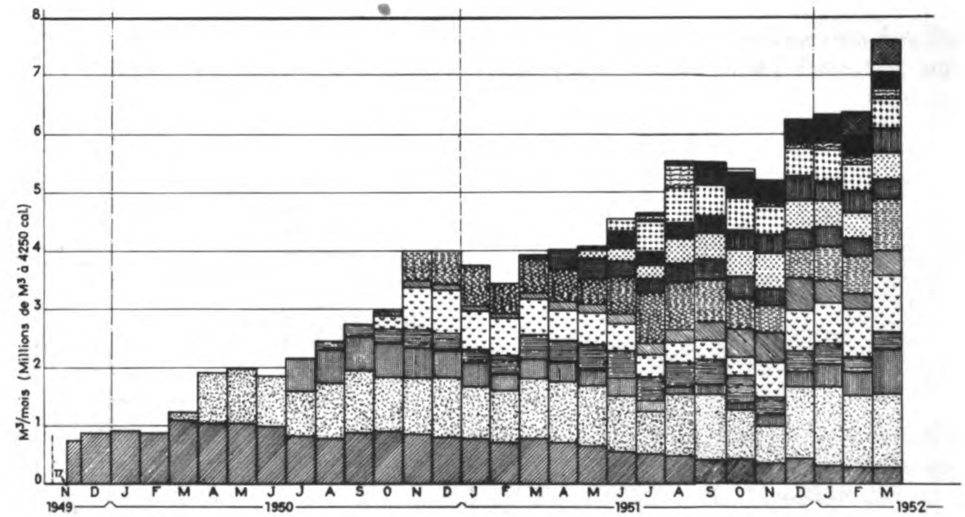

Figure 24. - Output of firedamp per ton of coal mined per colliery per month in the Hainaut Basins, Belgium.

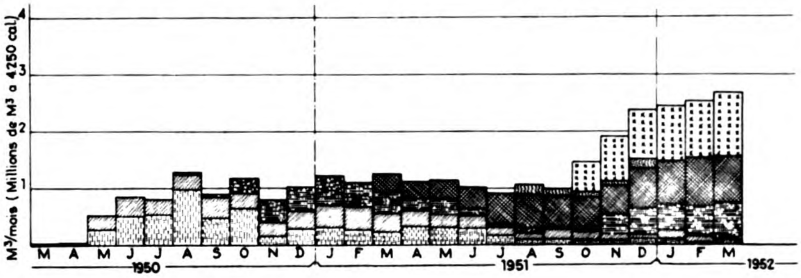

Figure 25. - Output of firedamp per ton of coal mined per colliery per month in the Campine Basin, Belgium.

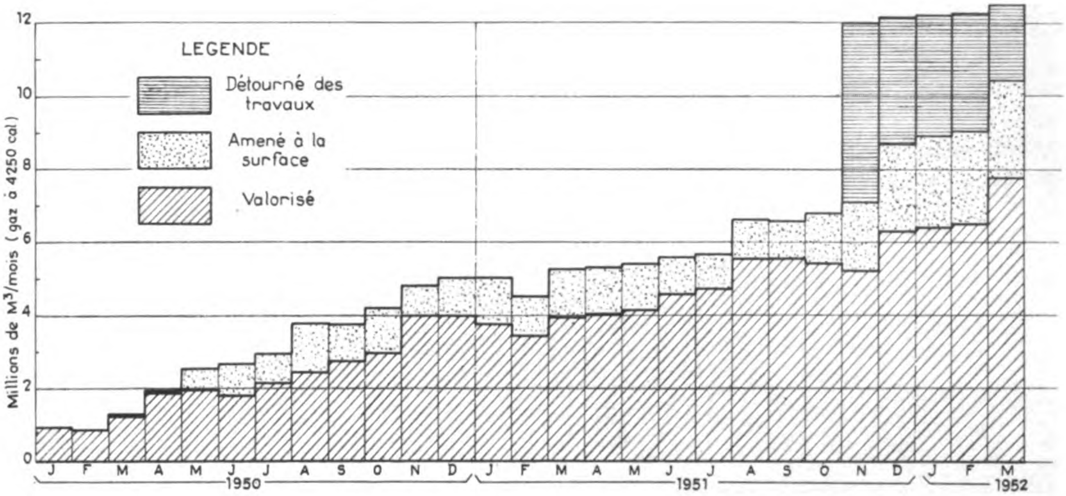

Figure 26. - Total amount of firedamp drained per day, divided into firedamp put to use, brought to the surface, and removed from the workings in Belgium.

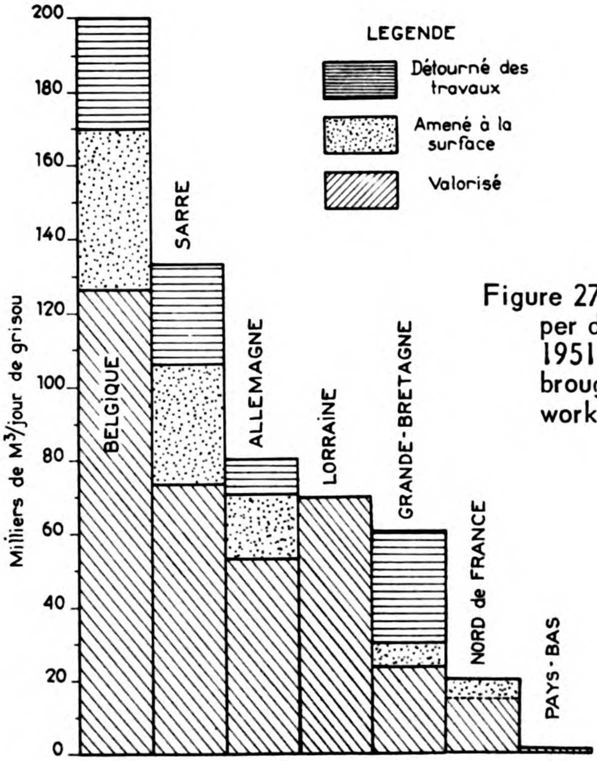

Figure 27. - Total amount of firedamp drained per day in each country up to the end of 1951, divided into firedamp put to use, brought to surface, and removed from workings.

Pit No.	Cu. m. per metric ton	Cu. ft. per short ton	Pit No.	Cu. m. per metric ton	Cu.ft. per short ton
1......	4	128	8.....	16.46	528
2......	8.43	270	9.....	23.37	749
3......	9.45	303	10.....	24.53	787
4......	12.48	400	11.....	28.95	928
5......	14.88	477	12.....	31.78	1,019
6......	15.19	487	13.....	73.58	2,360
7......	15.66	502			

Figure 23 shows the coalfields or parts of coalfields and the collieries where firedamp is drained, the coking plants, cracking plants, firedamp mains and ordinary gas mains, etc.

Figure 24 shows the output of firedamp er colliery per month.

The average amounts of firedamp obtained in the collieries of the Campine Basin follow for the month when firedamp output reached its maximum in the various collieries. These figures are comparable with those for the collieries of the Ruhr.

Pit No.	Cu. m. per metric ton	Cu. ft. per short ton
1	2	64
2	2.11	68
3	3.21	103
4	3.32	106
5	6.04	194

The diagram in figure 25 gives the output per colliery per month.

Firedamp is drained from only 1 or 2 working places in each colliery. In some working places the specific output of firedamp is high. It was pointed out at the firedamp conference in Mons, that at Les Liegeois colliery, 35 to 40 cu. m. of firedamp per metric ton (1,122 to 1,283 cu. ft. per short ton) was obtained in one working place.

An effective flame arrester has just been introduced in the Winterslag colliery by De Winter, managing director.

About 200,000 cu. m. (7,063,000 cu. ft.) of firedamp is drained per day in the whole of Belgium. Daily coal output is about 100,000 metric tons (110,000 short tons). The diagram in figure 26 shows the total amount of firedamp drained, divided into firedamp put into use, brought to the surface, and removed from the workings. The rise in the proportion of firedamp drained to the general gas output is remarkable. It was 2 percent in 1950, 5 percent in 1951, and is now 10 percent.

In the course of 1952, other collieries have been or will be connected to the general firedamp mains:

May 1952: Pits 17 and 19 of the Monceau-Fontaine colliery.
June 1952: Le Quesnoy pit of Bois-du-Luc colliery.
July 1952: Anderlues colliery.
September 1952: La Garenne pit of Maurage colliery.
October 1952: No. 14 of Monceau-Fontaine colliery.
December 1952: Ste. Elizabeth pit of Ressaix colliery.

It may be assumed, therefore, that by the end of 1952 21 pits in Hainaut will be connected.

At present the Limited Co. of the Monceau-Fontaine colliery has seven pits completely equipped and linked up with the Distrigaz mains. The total output of the company collieries is 50,000 cu. m. (1,766,000 cu. ft.) of methane per day. In another company, the sale of firedamp represents 5 percent of the value of the coal mine. There was also an increase in safety and output.

The diagram in figure 27 shows the total amount of firedamp drained per day in each country up to the end of 1951, divided into firedamp put into use, brought to the surface, and removed from the workings.

USE AND TRANSPORT OF FIREDAMP

The chief component of firedamp is methane. Systematic use of this gas in American and German industry caused an important development from a chemical point of view. The primary transformations of methane have given rise to a certain number of basic industries supplying hydrogen, mixtures of carbon monoxide and hydrogen, acetylene, ethylene, formaldehyde, hydrocyanic acid, and the whole series of halogenous byproducts.

These important raw materials, all obtained from methane, have helped many new processes to make rapid progress and should encourage fresh initiative in Belgium. Professor Ferrero dealt with this question at Mons on January 10, 1952, at the firedamp conference.

In spite of the advantage of using methane as a raw material, it is probable that, at the beginning at any rate, firedamp will be used by the gas industry. It is easy to transform it into normal 4,250 calorie (478 B.t.u. per cu. ft.) gas. A cracking plant has just been set up at Mont Ste. Aldegonde (Charleroi) by the Distrigaz Co. There are possibilities of using this domestic gas immediately as there are still large areas in Belgium without a gas supply.

Moreover, methane is not a new product in Belgium; about 250,000 cu. m. (8,829,000 cu. ft.) per day are produced in the residual gas of synthesis plants, and firedamp drainage produces about the same amount, thus doubling methane output. Some of the methane from the residual gas is used by the chemical industry, especially for production of hydrogen. One of the first destinations of firedamp drained from the mines is to join this methane and be put to the same use. In any case, the main means of getting the best use out of it is for the firedamp from several pits to be mixed, owing to the variations in quality and quantity usually observed at individual pits.

In this respect, Belgian achievements in Hainaut are remarkable. The gas grid system is extending daily. Soon all the pits and even the three Hainaut Basins will be connected. Thanks to a chemical factory, a cracking-reforming plant, and a mixing station in this network, it is possible to fulfill all requirements with the greatest adaptability.

In Campine various schemes have been evolved as a result of research. Some of them propose to put the firedamp to use and supply the Province with domestic gas at the same time. The schemes may be briefly summarized as follows:

(1) Setting up a production center in Campine for gas obtained from firedamp, to be used for domestic and industrial purposes.

From the domestic point of view alone, there are great possibilities in Campine. The example of the Netherlands Provinces of Limburg and North Brabant, where the evolution is fairly similar, may be quoted here.

In 5 years gas consumption there rose from 300,000 cu. m. (10,594,000 cu. ft.) to 600,000 cu. m. (21,188,000 cu. ft.) per day. For the entire Province of Belgian Limburg it is only a few thousand cu. m.

(2) At the end of 1950 the Distrigaz and Savgaz transport companies suggested two schemes which would unite all areas in Belgium producing and consuming gas. The two schemes propose installation of pipes of a total length of 52 km. (32.3 miles) to collect the firedamp from the 7 pits; gas mains would be laid between Campine and Liège and Campine and the urban districts of Brussels and Antwerp.

(3) Owing to the importance of the Campine pits, each of which has considerable technical possibilities, thought was naturally given to the possibility of putting the firedamp into use on the spot. It was suggested that firedamp should be used to produce mechanical energy in gas engines and for heating. Some of these suggestions are now being used.

(4) The problem of supplying the province with domestic gas also is being solved. Steps are now being taken toward a rational solution, which can be further developed later on. It consists of installing a gas main between Liège and Hasselt, which would enable all southern Limburg and part of the Province of Liège to be supplied with gas from Liege. The urban districts around Hasselt, Genk, Zonhoven, etc., would then be easily supplied by Hasselt, which would be the distributory center.

This plan is independent of the firedamp question. However, the Liège-Hasselt supply of ordinary gas of 4,250 calories would have to be doubled by a Hasselt-Liège supply of firedamp obtained from all the Campine coal mines. The two mains could be laid in the same trench.

Firedamp thus brought to Liège could be used there in the chemical factories capable of dealing with several tens of thousands of cubic meters per day (10,000 cu. m. = 353,000 cu. ft.). Thus maximum use of Campine firedamp would be achieved by its use for chemical purposes. The few collieries of the Liège region suitable for firedamp drainage could then also discharge their firedamp into the same mains, which would probably be the only way of making use of the firedamp from this area. The industrial needs of Limburg could also be covered from this double network of domestic gas and rich gas.

By linking Mons, Charleroi, Namur, and Liège, and double linking of Liège-Hasselt would achieve the complete connection of all the Belgian centers of production and consumption; it would consist for the most part of domestic gas mains and rich gas mains. It could be effectively completed by linking Hasselt- Brabant.

Such an intricate system would have great possibilities, particularly as it will be linked with neighboring countries.

SUMMARY

The production of firedamp was begun when the seam was formed from vegetable deposits in the coal marsh and continued throughout the long evolution into peat, brown coal, bituminous coal, and so on.

Some of this firedamp still survives in the coal seams. Recent research shows that it is released after expansion due to the working of the seam itself or a neighboring seam.

Firedamp is drained by collecting it before it mixes with the air of the mine. Various methods are being used.

The first drainage experiment took place in 1943 in Germany; the process is now carried out in this country, in Saar, France, Belgium, Great Britain, and the Netherlands. Belgium has contributed most to the development of drainage and use of drained firedamp; 12 percent of domestic gas of this country is produced from firedamp.

Drainage of firedamp offers the following advantages:

(1) Safety is improved by a considerable decrease in the percentage of methane in the ventilation air of gassy working places.

(2) Conditions are healthier because it is possible to decrease the volume of ventilation air and hence the amount of dust blown about.

(3) Very gassy seams can be worked with better output, owing to increased concentration and rate of advance.

(4) Drainage of firedamp enables rich gas, consisting almost entirely of methane, to be collected and put to good use.

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